

An Examination of Expert System Uses in Power Plants

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Abstract: Power generation control becomes progressively more complex as equipment dimensions and power output capabilities increase in the industry. Professional operators who understand plant systems need to be employed because they must make various operational decisions throughout the power plant. The modern power industry faces a primary challenge owing to the shortage of professional plant operators with proper skills and experience. The field of plant automation now focuses on artificial intelligence expert systems because these programs specifically replicate the operations of professional plant operators. This study conducts an analysis of numerous expert system implementations occurring in electric power plants. The evaluation demonstrates how expert system technology progressed through its combination with modern approaches that include fuzzy, neural network, machine vision, and data gathering systems. The use of expert systems to conduct plant fault diagnosis and maintenance enables a decreased workload for professionals as well as plant operators. The applications of expert systems include data processing as well as alarm reduction and schedule optimization and operator training and evaluation functions. The traditional rule-based methods combined with contemporary approaches which include neural networks, fuzzy logic, machine vision, databases and simulators have expanded expert systems' capacity to solve problems.

Keywords: Fuzzy Logic, Neural Networks, Expert Systems, Fault Diagnosis, Alarm Processing, Operator Support
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I. Introduction

Nationwide economic development depends heavily on the power facilities installed within its borders. The transformation of nonelectrical energy takes place into electrical energy at power plants. All energy transformation facilities at power plants can be grouped into fossil, nuclear, solar, geothermal, hydro, wind and other categories. The plant consists of many complex devices which include turbines and generators together with transformers and protection and control units. The rise of advanced power generating units together with increased plant capabilities make power plant control and operation more intricate. Trustworthy operation of the power plant rests with human specialists. The professionals require expertise-based decision-making along with heuristic methods as well as rational reasoning and intuitive knowledge to support their work [7-9].

The power industry faces a shortage of capable personnel which drove this sector to implement modern approaches for facility control of power generation operations. The quick expansion of computer and information technology enables power plant operation management to fully use both computer-aided tools and data collection systems. Power plants use artificial intelligence as a common method to reduce working staff requirements through atomization processes. The components of artificial intelligence consist of fuzzy logic, genetic algorithms, neural networks and especially expert systems that function to duplicate the decision-making process of experts.

Experts have built numerous systems for power plant supervision and control throughout the last thirty years. Expert system technology brings its best capabilities to fault diagnosis because this application duplicates how expert plant operators solve problems. The applications of expert systems include power plant design together with alarm processing and data analysis and plant maintenance in addition to fault prediction and operator training and evaluation. The techniques and technologies utilized by developers of expert systems in power generating facilities appear in the ensuing sections. The analysis mainly explored different application sectors together with technological aspects employed by expert systems.

II. Expert Diagnosis System Failure

Expert systems show the most critical use in power plant fault diagnosis operations. An expert system operates as an expert human being during fault detection functions. System restoration through repair strategies with simultaneous detection instructions for operators is described by the system in order to fix faults quickly. An expert system requires the knowledge base to serve as its essential framework. The three main categories of expert systems are rule-based, fuzzy-based and hybrid expert systems depending on their chosen technique for defect diagnosis. Heuristic rule-based expert systems served as the initial approach for storing plant information gathered from books and manuals as well as the knowledge of plant experts within the if-then format. Forward and backward inferencing methods together with hybrid reasoning helped achieve correct solutions on the knowledge base. Experts can achieve correct results from the system when the knowledge rules ensure thorough clarity.

The authors Kraft et al. created and examined a dual expert system which unites a rule-based architecture with a neural network for thermal plants applications [8]. The training of a fully recurrent neural network occurs through data acquired from multiple sensors mounted on plant equipment to derive time series patterns. The expert system operating on rules examines how measured values differ from network predictions. The system activates rules which suggest corrective remedies throughout time periods of abnormal plant operations. The monitoring system exists for detecting issues within boilers of fossil fuel power plants. Neural network models prove highly useful in developing simulations that replicate the complex time-based operations of plant features. A neuro fuzzy hybrid integrated system prototype developed by Jae and team allows experts to inspect steam generator tubes in nuclear power plants [6]. The system incorporated successful implementations of distributed computing and robotics as well as machine vision and remote monitoring and artificial intelligence. The knowledge base for the prototype contained about 600 rules. Expert system assisted inspections demonstrate through tested results that they reduce time and expert requirements to one-third of their original values [9].

III. Clearing Overload and Predicting Loads

Personal responsibility for power plant operators consists of reducing both the extent and length of system overloads. A specific mathematical formulation does not exist to represent overload cleaning operations. Operating power plants requires competent individuals with detailed expertise to carry out the required procedures. Negativity et al. established an online rule-based expert system which improves operator decision-making through suitable control actions [7]. A method utilizing network sensitivity factors establishes the required control actions while determining the number of corrections needed to clear overloads. The proposed system serves real-time operating conditions of the plant through instantaneous single or double second instructions. An expert system that allows online lookup load-shedding table creation was developed by Delfino et al. [4]. The respective system makes use of static and dynamic simulation methods for offline validation of proposed load shedding procedures. This operator assistance tool made the load shedding process more flexible and suitable for operation continuity.

Digital value changes states in power system control centers trigger alarms while analogue values exceeding threshold values from transducers activate alarms. Application applications inside control center environments and other linked computers send out alert messages to their users [1]. According to the Power System Control Centers Joint Working Group report excessive alarms stand as a definite problem especially when emergency assistance is needed [2]. The alarm-processing challenge exists in the interpretation of numerous alerts during stressful situations such as disturbances and defects by providing brief synthesized data instead of raw alarm data [3]. Modern SCADA systems make use of intelligent alarm processing features such as priority assignment and filtering in their implementations. The present version of alarm processing software does not satisfy operator requirements for system monitoring despite multiple solutions already being developed. The symbolic processing capabilities of expert systems make them appropriate for solving alarm processing problems.

IV. Training for Operators

One of the main issues facing the power industry is the lack of skilled and experienced operators. Despite their qualifications, recently hired operators cause issues because they lack expertise and understanding of the intricate power system gear. According to surveys, operators of power plants make mistakes because they don't know enough about the issue, which leads to mishaps. This highlights how important it is to train the less experienced operators. Operator training is often conducted by human subject-matter specialists. They instruct the operators on the nature and operation of the system and share their factory knowledge. Computer-based simulators have been used for training for more than 20 years. They assist the operators in creating scenarios that could occur while the plant is operating.

Despite their excellent use and technological adaptation, they are not very appealing from an economic standpoint. The use of artificial intelligence approaches in the field of operator training is being investigated by researchers [6-9].

V. Conclusion

A survey of several expert system applications in power generation plants is presented in this work. Expert system technology plays a crucial role in power plant management, according to the review. Accidents caused by inexperienced operators making poor decisions can be avoided with a well-designed expert system. It can significantly lower the number of workers needed for plant control. There were a number of drawbacks to earlier rule-based expert systems. Later developers improved expert systems decision-making capacity through implementations of fuzzy logic along with neural networks and real-time databases and algorithmic processing logic beyond the traditional rules [9]. The complex nature of power plant management processes and their non-linear characteristics excludes the usage of a single technique when building modern expert systems. Multiple artificial intelligence and learning methods combined lead to improved performance for expert systems. The combination of knowledge base systems with today's computer networking along with information system improvements makes the development of secure adaptable power plants possible.

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